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# Rasmussen, Chenery and Watanabe, and labour-based multiplier analysis and sensitivity analysis of input coefficients for Spain in 2009

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# RASMUSSEN, CHENERY AND WATANABE, AND LABOUR-BASED MULTIPLIER ANALYSIS AND SENSITIVITY ANALYSIS OF INPUT COEFFICIENTS FOR SPAIN IN 2009

## ABSTRACT

In this paper we identify the key sectors of the Spanish economy with the last input-output available data following the approaches by Rasmussen and by Chenery and Watanabe. We also calculate labour-based multipliers and sensitivity of input coefficients and we compare the results in order to present useful advice for sector policies.

Keywords: key sector, multipliers, input-output

## RESUMEN

En este trabajo analizamos cuáles son los sectores claves en España con los últimos datos publicados del marco input-output. Seguimos las metodologías de Rasmussen y de Chenery y Watanabe. También hacemos uso de los multiplicadores de remuneraciones, trabajadores y asalariados así como de la técnica de sensibilidad de coeficientes. En las conclusiones se presentan los principales hallazgos que permiten diseñar una política sectorial eficaz para España.

Key words: sector clave, multiplicadores, input-output

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## INDEX

## 1. INTRODUCTION

This paper focuses on the identification and evaluation of the key sectors of the Spanish economy from the data included in the input-output matrix for 2009. These key sectors are obtained following different criteria, combining Rasmussen and Chenery and Watanabe multipliers approaches and the widely used analysis of sensitivity of the coefficients. These approaches allow classifying the sectors according to their potential impacts on the whole economy. Thus we can calculate which sectors have the greatest potential impact, those are called key sectors.

We also perform a calculation of labour-based multipliers. These non-traditional multipliers allow estimating the sectors with a higher impact on wages and employment. These multipliers provide a key answer to the analysis to improve the sector economic policy in Spain. We have to take into account that when Spaniards are asked for the main three problems in their country, more than 75% include unemployment among them. Political corruption is a problem for only one half of the respondents and other issues such as crisis or health system are problems for less than a quarter of the population (CIS, 2015). Then, it is essential to include these multipliers in the analysis in order to design a meaningful sector policy.

In this article the importance of the productive sectors is calculated by means of the input-output matrices. The underlying idea of every method is finding the sectors with the highest degree of interrelation. These sectors play a major role boosting the economy. The first well-known researchs in this field were performed in the early fifties, when Chenery and Watanabe (1958) and Rasmussen (1956) proposed different measures of linkages. They based their multipliers in input (technical) coefficients and in the Leontief inverse, respectively. These approaches allow making classifications between sectors that, in any case, are not very different under both criteria.

Furthermore, Rasmussen introduced the concept of key sector as an economic sector with high dispersion capability. This suggests the sector has a high impact on the system. Generally a key sector depends greatly in the total system and vice versa. This concept should not be regarded as an absolute truth since it depends on the policy objectives. These objectives can be focused on employment and output increase with a different degree. Furthermore, other problems such as environment protection and reduction of imports dependence may arise and Rasmussen multipliers cannot cope with them.

An input-output matrix presents the balance between supply and use of goods and services in an economy at sector level in a bidimensional table. In addition it shows a description of the economy of a country or

a region during a given period. The input-output matrix allows analyzing and quantifying the levels of sector production that permit distinct levels of consumption and investment in the economy. Thus it is possible to project production needs as a result of an increase in demand. Input-output matrices are considered one of the main data sources for economic policy and are especially relevant in socialist economies and capitalist economies with significant sector regulations such as the countries of the European Union.

The input-output matrix can be divided into three matrices: the first one is the intermediate demand. It includes supply chain purchases (columns) and sales (rows) between the different sectors of the economy; the second one is the added value and it is located in the bottom. It has information about the portion of the income that compensates capital (recorded as gross operating surplus) and labour (compensation to employees) as well as taxes less production subsidies; and the third one is the final demand usually located in the right. It shows the transactions with respect to the use of processed products, ie consumption by households, government consumption, investment (gross fixed capital) and the variation of stocks. Sometimes exports and imports are introduced and then it is called extended Leontief model or open economy input-output matrix.

There are at least three recent examples of input-ouput analysis performed for the Spanish economy: Robles & Sanjuán (2008), Guerra & Sancho (2010) and Cansino et al. (2013) They use data of input-output matrices from 1995, 2004 and 2007 respectively.

Robles & Sanjuán (2008) discuss about the concept of key sector, its importance and the convenience of using more than one approach to calculate them. They use Rasmussen and Chenery and Watanabe well-known approaches in an input-output matrix of 70 sectors. Later they perform coefficient sensitivity analysis and Dietzenbacher eigenvalue approach. The authors conclude coefficient sensitivity analysis might be useful and eigenvalue approach does not solve the problems of traditional methods. Finally they carry out a novel cluster analysis useful to determine not only key sectors but key clusters of sectors. Nevertheless, this approach can be critized as it is nonstandard and therefore the results could include errors and artefacts.

Guerra & Sancho (2010) compare Rasmussen method with the Hypothetical Extraction Method that measures the role of a disappearing sector. They present an hybrid approach and apply it to the Spanish case (17 sectors) to identify key sectors for energy efficiency policies.

Finally, Cansino et al. (2013) use the data of the Social Accounting Matrix (26 sectors) to calculate key sectors according to Rasmussen multipliers and the Hypothetical Extraction Method. They also apply

coefficient sensitivity analysis and they conclude the key sectors are related to energy, industry and construction activities.

We get to a symmetric input-output matrix with 71 sectors from the input-output matrix provided by the National Statistics Institute (INE). The initial available matrix has 109 rows and 74 columns. We apply the transformations shown in Table A1 in the Annex. Most of the sector joints are in the rows as it could be expected. There are only four sectors joined in two pairs in the columns: 1) Truck, pipeline, transit and ground passenger transportation; and 2) Wholesale trade and retail trade. After these mandatory sector simplifications we get a simetric matrix of 72 sectors and we drop Domestic workers as it has no positive value in the corresponding row and column.

Next, in the second section the technical coefficients are calculated and the sensitivity analysis implemented. In section 3 production linkages are studied using the techniques described by Rasmussen and Chenery and Watanabe. Following, in Section 4 the analysis of other multipliers on employment and compensation to employees is performed. Finally, general conclusions are presented in a summary table comparing the results of the article.

## 2. SENSITIVITY ANALYSIS OF INPUT COEFFICIENTS

The input coefficients can be obtained from any input-output matrix regardless of whether is or is not square. We opted to perform the analysis with the 71x71 square matrix in order to compare the results with other approaches that need square matrices.

These input or technical coefficients represent the necessary quantity of goods, expressed in monetary units, to produce one unit of another good. From a macroeconomic point of view, they are defined as the needs of products of a sector to make or manufacture from components or raw materials. Specifically, these coefficients include intermediate inputs (goods or services) a sector needs. These inputs are produced other sectors or the same sector in other productive units. The input coefficients are usually expressed as the percentage of the value of production (total demand) of a sector that purchases goods or services from the same or other sectors. Input coefficients are usually denoted as $a_{ij}$ and are equal to the sales of sector i to sector j divided into the production of sector j. Thus, they include needed inputs of i to produce a unit of sector j.

We determine the relative importance of the coefficients before performing the linkage analysis, ie, to which extend a sector can generate significant changes in both production and demand of other

sectors. Any $a_{ij}$ coefficient can be large, but in the sector j has a small production, the effect of a change in sector i might be not significant. Furthermore, the $a_{ij}$ coefficient may be of medium size, but can have a big impact if production in sector j is large enough.

Sensitivity studies allow classifying coefficients between the important ones and those merely large. It is possible to highlight those that may cause major changes in production. A small set of coefficients called Most Important Coefficients (MIC) can be calculated. The number of them in each sector indicates its importance or influence on the production system (Forssell, 1988).

To set the limit on what can be considered a MIC there are techniques such as the tolerable limits approach introduced by Sekulic (1968) and Jilek (1971) and developed by Aroche-Reyes (1996. A coefficient $a_{ij}$ is important if a variation lower than its amount causes a change larger than a given level which is usually established at 0.5% or 1% of total production in any sector. The formula for the sensitivity coefficients is:

$$w_{ij}(p) = a_{ij}\left(I_{ji}p + Iii\frac{X_j}{X_i}\right) \quad (1)$$

Where $a_{ij}$ is the input coefficient, $I_{ji}$ and $I_{ii}$ are elements of the Leontief inverse matrix, , $X_j$ and $X_i$ are the total production of the respective sectors, and p is defined as the minimum percentage to be consider a coefficient as MIC (1% in our case). It is generally computed as:

$$r_{ij} = \frac{p}{w_{ij}} \quad (2)$$

The more important the technical coefficient $a_{ij}$ the lower the value of $r_{ij}$ will be. $r_{ij}$ indicates the minimum variation that can have the coefficient from which the sector's output is modified by more than p. After computing the values of $r_{ij}$ the following classification is used:

- Most Important Coefficients (MIC): $r_{ij}$ <0.1
- Quite important coefficients: 0.1 ≤ $r_{ij}$ <0.5
- Little important coefficients:0.5 ≤ $r_{ij}$ <1.0
- Coefficients with no importance: $r_{ij}$ ≥ 1.0

The coefficients for the same sector (i=j) are eliminated because depending on how the sectors are aggregated they may vary to a great degree. Also, the aim is to quantify the intersector relations and therefore those coefficients are not considered appropriate as they include the self-consumption in the sector. Out of the 4645 coefficients 92.14% are not important (4685), 2.70% as classified as quite important (136), 3.17% are little important (160) and only 0.58% as the most important coefficients (29). As aforementioned, the main advantage of this approach is it allows selecting only a small amount of important coefficients.

This classification implies that the presence of a significant number of MIC in a row for a given sector shows that the sector has a high relevance for the production of other sectors. In the case that the most important coefficients are in the column it indicates that the sector induces significant increases in the production of other sectors as a result of its intermediate consumption.

Table 1

**Key sectors according to sensitivity analysis of input coefficients**

| Key sector | MIC by rows | MIC by columns | Total MIC |
|---|---|---|---|
| Vehicle manufacturing | 6 | 0 | 6 |
| Petroleum refineries | 5 | 1 | 6 |
| Farming | 4 | 1 | 5 |
| Chemical manufacturing | 4 | 0 | 4 |
| All other food manufacturing | 3 | 1 | 4 |
| Mining and quarrying | 2 | 1 | 3 |
| Electric power generation and transmission, and natural gas distribution | 1 | 2 | 3 |
| Iron and steel mills and ferroalloy manufacturing | 2 | 0 | 2 |
| Fabricated metal manufacturing, except machinery and equipment | 1 | 1 | 2 |
| Fishing | 0 | 2 | 2 |
| Milk and derivatives manufacturing | 0 | 2 | 2 |
| Beverages manufacturing | 0 | 2 | 2 |
| Air transportation | 0 | 2 | 2 |

Source: Authors' elaboration.
Only sectors with total MIC higher than one are included in the table.

The key sectors for the production of other sectors are vehicle manufacturing (6 MIC) and petroleum refineries (5 MIC). Chemical manufacturing (4 MIC) produces also one of the main input of a number industries. Farming (4 MIC) as well as other food manufacturing sector (3 MIC), supply food manufacturing industries and trade and food and drinking places respectively.

The key sectors that require large amounts of inputs from other sectors are spread and are twenty-four sectors with at least one MIC by columns versus just eleven sectors with MIC by rows. In this case no sector can be especially highlighted because the maximum number of MIC by sector is two. This shows that the Spanish economy has some critical sectors from the supply point of view as their production is used as a necessary input for various sectors, but has no sector that is particularly relevant as the sole consumer of more than two sectors. This fact shows the Spanish economy would be reasonably well prepared to face sizeable reductions in the production of any sector without any major negative backward effect in the supply chain. However, the forward effects of an unforeseen downturn at sector level could be significant in some cases.

## 3. LINKAGE ANALYISIS

The seminal articles by Rasmussen (1963), Hirschman (1961) and Chenery and Watanabe (1958) studied the interrelationships of the input-output matrix to propose different calculations with the aim of classifying sectors according to their importance. These criteria are based on two types of linkages: i) backward linkages measure the potential of a sector to pull other related sectors throught its demand for intermediate goods and stimulating, in turn, the activity of such sectors; and ii) forward linkages measure the potential of a sector to push other ones through its supply capacity demanded by them.

The article by Chenery and Watanabe (1958) proposes calculating direct backward and forward linkages based on the input coefficients of the input-output matrix. Thus, direct backward linkages are calculated as:

$$DBL_j = \frac{\sum_i X_{ij}}{X_j} = \sum_i a_{ij} \qquad (3)$$

and direct forward linkages as:

$$DFL_i = \frac{\sum_j X_{ij}}{X_i} = \sum_j a_{ij} \qquad (4)$$

Using $DBL_j$ and $DFL_i$ values Chenery and Watanabe propose the following classification:

Table 2

**Sector types according to Chenery and Watanabe**

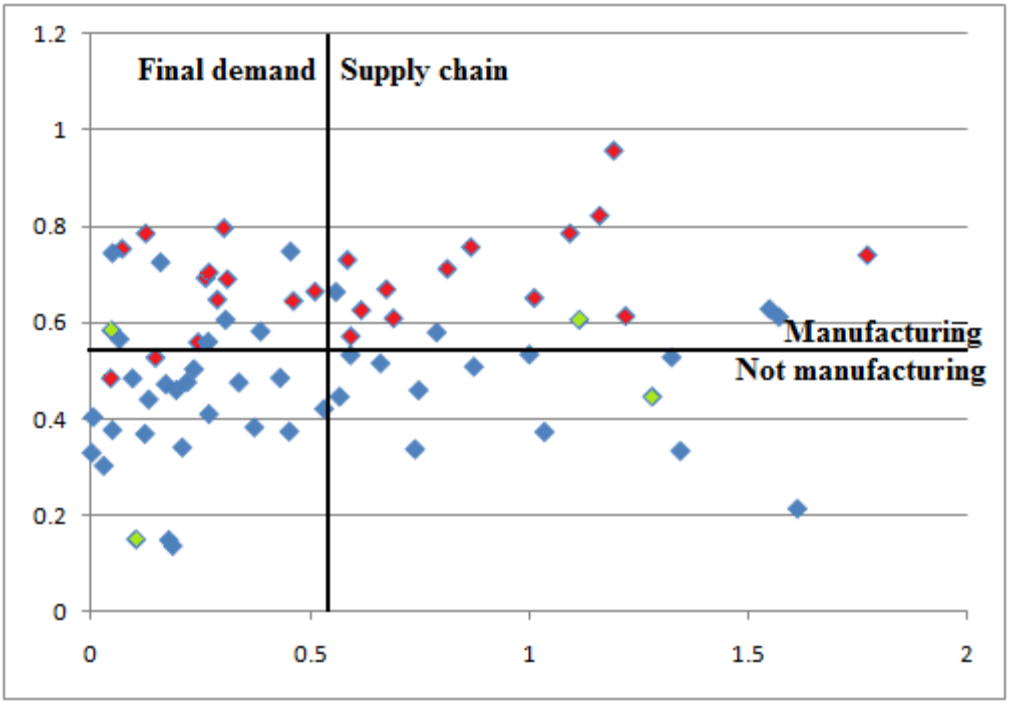
| | **$DBL_j$<average** | **$DBL_j$≥average** |
|---|---|---|
| **$DFL_i$<average** | Not manufacturing / Final demand | Manufacturing / Final demand |
| **$DFL_i$≥average** | Not manufacturing / Supply chain | Manufacturing / Supply chain |

Source: based on Schuschny (2005)

- Not manufacturing / Final demand: No significant purchase from other sectors so they are considered primary production. Neither they sell their products to other sectors in a significant amount.
- Manufacturing / Final demand: These sectors purchase from other sectors high amounts of inputs, but most of their production is consumed by individuals.
- Not manufacturing / Supply chain: They sell to other sectors an important portion of their production and therefore have high forward linkages and low backward linkages. They are intermediate primary production sectors.
- Manufacturing / Supply chain: They are sectors that purchase large quantities of inputs and sell their production to other sectors.

Graph 1

**Sector types according to Chenery and Watanabe in Spain (2009)**




Source: Authors' elaboration.
Green: Primary sectors in green, Industrial sectors in red, Services in blue.

Industry activities are divided into 25 sectors. The graph shows how they match almost perfectly with the classification of manufacturing sectors. Some industries are oriented to supply goods to other sectors and other devote most of their production to final demand.
Primary sector is divided into 4 sectors: Farming and mining and quarrying are considered more oriented to supply chain while fishing and forestry and logging sell a higher portion of their production to other uses rather than supply chain. In this case the clients might not be end consumers but a significant portion is exported.

Services activities are are divided into 42 sectors. Most of them tend to offer their services to final demand but there are also several business oriented services. Due to the input-output structure of their activities some even have manufacturing nature as is the case of water and air transportation, which are classified as manufacturing sectors that sell most of their production to final demand.

Additionally, the total linkages can be calculated using the elements of the Leontief inverse matrix $b_{ij}$ instead of the technical coefficients $a_{ij}$. These linkages not only consider the direct effects but also incorporate

the indirect effects within the multiplier effect. Total backward linkage can be calculated as:

$$TBL_j = \sum_i b_{ij} \quad (5)$$

And total forward linakage would be:

$$TFL_i = \sum_j b_{ij} \quad (6)$$

Table 3

**Chenery and Watanabe Multipliers for Spain in 2009**
**(sectors with highest and lowest linkages)**

| Sector | Direct Backward Linkage | Direct Forward Linkage | Total Backward Linkage | Total Forward Linkage |
|---|---|---|---|---|
| Chemical manufacturing | 1.77 | 0.74 | 6.42 | 3.00 |
| Electric power generation and transmission, and natural gas distribution | 1.55 | 0.63 | 5.68 | 2.61 |
| Mining and quarrying | 1.11 | 0.61 | 6.05 | 2.53 |
| Petroleum refineries | 1.19 | 0.96 | 4.51 | 3.59 |
| Warehousing and storage | 1.57 | 0.61 | 5.37 | 2.45 |
| Iron and steel mills and ferroalloy manufacturing | 1.09 | 0.79 | 4.33 | 3.07 |
| Vehicle manufacturing | 1.16 | 0.82 | 3.59 | 3.44 |
| Fabricated metal manufacturing, except machinery and equipment | 1.22 | 0.62 | 4.36 | 2.65 |
| Construction | 1.33 | 0.53 | 4.62 | 2.21 |
| *Sector average* | *0.54* | *0.54* | *2.31* | *2.31* |
| Community care facilities and services | 0.00 | 0.41 | 1.00 | 1.91 |
| Government, defense and social insurance | 0.03 | 0.30 | 1.05 | 1.66 |
| Educational services | 0.19 | 0.14 | 1.40 | 1.31 |
| Employment services | 0.18 | 0.15 | 1.39 | 1.29 |
| Attributed property income | 0.00 | 0.33 | 1.00 | 1.56 |
| Forestry and logging | 0.10 | 0.15 | 1.27 | 1.35 |

Source: Authors' elaboration.

The most relevant sectors according to the multipliers by Chenery and Watanabe are chemical manufacturing, electric power generation and transmission, and natural gas distribution, mining and quarrying and petroleum refineries. These activities have the highest direct and total backward linkages. We can also highlight warehousing and storage activities, metalworking, vehicle manufacturing and construction as other sectors with remarkably high backward and forward linkages.

Opposite, the sectors with lower linkages are mostly services to individuals as could be expected. They do not use a significant amount of inputs and these activities are not part of the supply chain. Forestry and logging sector has few backward linkages as it requires a few amount of inputs and these activities focus their sales in pull and paper mills so this sector either has important linkages forward and also appears as unimportant following this approach.

In Addition to the approach by Chenery and Watanabe, Rasmussen (1963) combines the study of the linkages between sectors with the importance of the spread or dispersion, ie, the degree to which a sector can affect more or fewer sectors, independently of the linkage degree. First the power of dispersion is defined, that is, the size of the average effect of an average sector to the rest of sectors. This is calculated as the effect of one unit increase in net final demand of the sector into the average effect of one unit increase of the economy. It can be calculated as:

$$\pi_j = \frac{TBL_j}{\left(\frac{\sum_j TBL_j}{n}\right)} = \frac{n \sum_i b_{ij}}{\sum_i \sum_j b_{ij}} \qquad (7)$$

Where $\pi_j$ is the power of dispersion of sector j. For $\pi_j>1$ the effect is greater than the average of the economy, while if $\pi_j<1$ the effect is lower than the average of the economy. The disadvantage of $\pi_j$ is that it does not allow observing how the impacts spread across sectors. This approach also assumes the impacts are dispersed uniformly across sectors. The variation coefficients are calculated to compute the spreading impact of a sector. The impact of sector j-th is defined as:

$$\varphi_j = \frac{n}{TBL_j} \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} \left(b_{ij} - \frac{TBL_j}{n}\right)^2} \qquad (8)$$

Therefore, a large value of $\varphi_j$ means the sector purchase most of the inputs from few sectors of the economy and vice versa. The lower the value, the greater the impact of changes in production since this variable measures the dispersion. Then a higher value would represent a the effect is shared among more sectors and the concentration would be minor. The variable shows to which extent the sector j weighs on the production system.

Finally, it can be defined forward linkage following the same reasoning. It shows the degree of sensitivity of the dispersion:

$$\tau_i = \frac{TFL_j}{\left(\frac{\sum_j TFL_j}{n}\right)} = \frac{n \sum_j b_{ij}}{\sum_i \sum_j b_{ij}} \qquad (9)$$

If $\tau_j > 1$ the effect is greater than the average of the economy, while if $\tau_j < 1$ the effect is lower than the average. This variable shows the dregree of sensitivity of a sector to general changes in demand. This allows calculating which sectors are more sensitive to changes after shocks of output, employment and income.

Table 4

**Sector types according to Rasmussen**

| **Type I** | | |
|---|---|---|
| | $\pi_j < 1$ | $\pi_j \geq 1$ |
| $\varphi_j \approx \varphi_j min$ | Sectors with dispersed low pushing effect | Key sectors (Type I) |
| $\varphi_j \gg \varphi_j min$ | Sectors with concentrated low pushing effect | Sectors with concentrated high pushing effect |
| **Type II** | | |
| | $\pi_j < 1$ | $\pi_j \geq 1$ |
| $\tau_j \geq 1$ | Strategic sectors | Key sectors (Type II) |
| $\tau_j < 1$ | Independent sectors | Pushing sectors |

Source: based on Schuschny (2005)

As we have seen, a large dispersion potential value indicates that this sector have strong effects on other activities. Then, a sector of this type will depend largely on the level of activity of other sectors. Then we can consider this type of sector as a key sector (Type I). In this regard, a key sector has a largest value of $\pi_j$ and a small value of $\varphi_j$. In the case of an increase in final demand for their products, it would lead to a relatively large increase in the demand in other sectors.

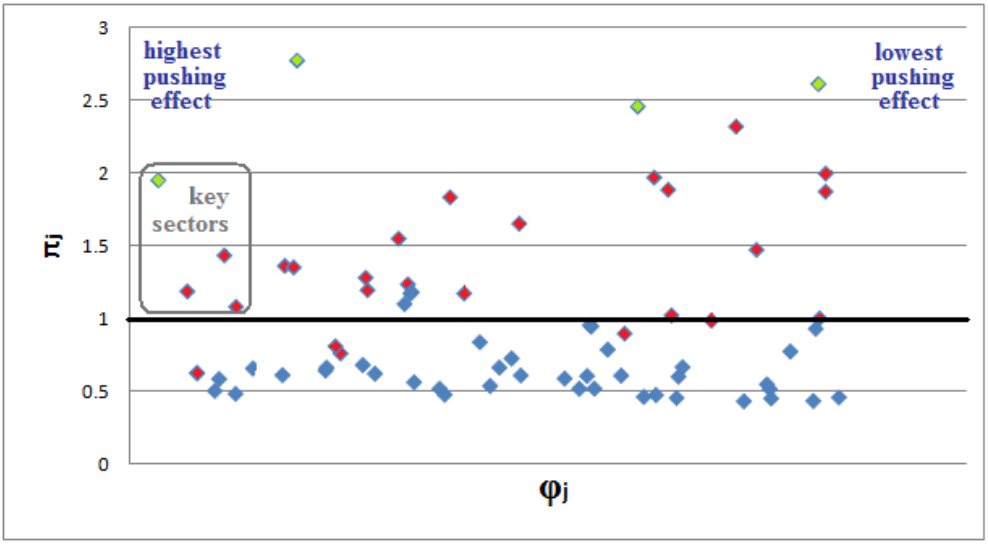
Another approach that is often used to identify key sectors (type II) is to discriminate the sectors whith values $\pi_j$ and $\tau_j$ greater than the unit. Table 4 shows the two types of classifications by Rasmussen.

The first type allows classifying low and high pushing sectors, and whether their effect is concentrated in a few sectors or not. In the right part of Graph 2 appear the sectors with the lowest pushing effect appear. These sectors with little pushing effect are fishing, milk and derivatives manufacturing, tobacco product manufacturing and all other transportation equipment manufacturing. In addition to have a scarce effect it is concentrated in just a few sectors in the case of community care facilities and services, attributed property income, rail and water transportation.

On the left side of the Graph 2 the sectors with the highest pushing effect are located. Those that concentrate their effect are electric power generation and transmission, and natural gas distribution, truck, pipeline, transit and ground passenger transportation, warehousing and storage, financial investment services and government, defense and social insurance. The key sectors according to the first type defined by Rasmussen are mining and quarrying, chemical manufacturing and metalworking activities.

Graph 2

**Sector types according to Rasmussen-Type I in Spain (2009)**




Source: Authors' elaboration.

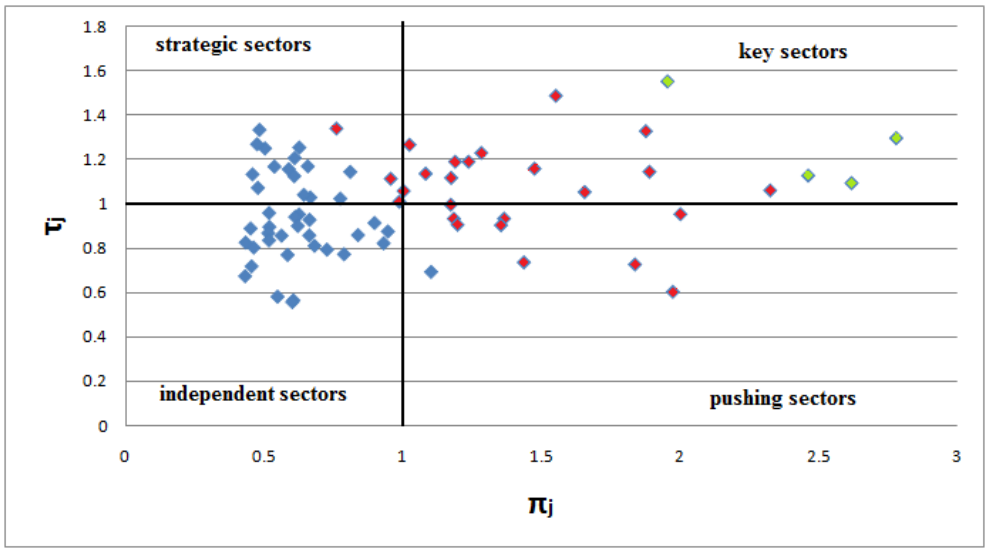
Green: Primary sectors in green, Industrial sectors in red, Services in blue.

The second type by Rasmussen allows dividing the sectors in four categories:

- Pushing sectors have a great impact as produce important inputs. Promoting them has positive effects of great magnitude on other sectors.
- Strategic sectors are those that depend largely on the performance of other sectors and therefore they have a high degree of dependency on the rest. Their growth affects other sectors that provide them inputs.
- Key sectors are those with a high pushing capacity on others and are also conditioned by other sectors. Accordingly, they are configured as the sectors with the highest importance.
- Finally, opposite to the previous group, independent sectors have an interdependence lower than the average both as consumers and suppliers in the supply chain.

Graph 3

**Sector types according to Rasmussen-Type II in Spain (2009)**




Source: Authors' elaboration.

Green: Primary sectors in green, Industrial sectors in red, Services in blue.

The key sectors according to this second type are mainly the four subsectors that are in the primary sector. They are the ones that show the highest backward and forward effects. Also some manufacturing activities are key sectors: Animal slaughtering, rendering, and processing, milk and derivatives manufacturing, all other food manufacturing, beverages manufacturing, fabric mills, leather and allied product manufacturing, paper mills as well as paperboard mills and printing.

As it can be seen all these key sectors are part of the primary sector or manufacturing traditional goods. Chemical manufacturing is also a key sector as it happened with alternative approaches. Other key sectors with small linkages are pharmaceutical preparation manufacturing, miscellaneous nonmetallic mineral products (mainly cement and glass manufacturing), iron and steel mills and ferroalloy manufacturing and all other transportation equipment manufacturing. All of them are manufacturing sectors and as it can be seen in Graph 3 services are the less relevant sectors in terms of pushing and pulling effects according to this methodology.

## 4. LABOUR-BASED MULTIPLIER ANALYSIS

In addition to the aforementioned traditional multipliers there are other multipliers that should be taken into account when making this type of analysis, especially when employment is the main objective of economic policy such as in Spain. These multipliers are the ones for wages that allow observing the sectors that generate the highest income to workers, and the employment multipliers, that show which sectors that create the highest employment level for each monetary unit produced.

In the case of the compensations to employees, the coefficients are calculated as:

$$w_j = \frac{comp_j}{X_j} \tag{10}$$

It is the direct effect on the sector. In order to get the total effect it is necessary to multiply the coefficient $w_j$ by the Leontief inverse matrix.

This multiplier for the Spanish economy is between 0.194 for real estate actitivies and 0.907 for employment services, so for each additional euro asigned to this sector more than 90% would be devoted to remunerate the labour factor. Besides this sector that has the highest effect on wages, other key sectors for compensation to employees are: education services (0.802), investigation and security services, services to buildings and dwellings and other support activities (0.788), scientific research and development services (0.749) and mainly the activities categorized as personal services, that is activities primarily focused on providing services to citizens instead of other companies. These sectors do not usually appear as key ones in traditional approaches such as the ones calculated in the previous section.

The effect on employment can be disaggregated in total employment and workers. Thousands of full-time jobs per year to prevent the multipliers are affected by the rate of part-time and temporary employment that differ greatly between sectors. To calculate these ratios the number of employees is divided into the total production and the vector is multiplied by the Leontief inverse matrix.

The sectors that generate more jobs for each euro obtained are the employment services, other personal services and investigation and security services, services to buildings and dwellings and other support activities. Taking into account only the full-time equivalent employees, these three activities still appear at the top but investigation and security services, services to buildings and dwellings and other support activities ranks second because in other personal services there is a higher rate of self-employment.

The sectors that generate the lowest employment per euro are attributed property income, real estate, financial investment services, telecommunications carriers and electric power generation and transmission, and natural gas distribution. These sectors need more capital than labour to develop their activities and they have the highest value in the ratio of sales per employee.

## 5. CONCLUSIONS

Key sectors are not the same under all the approaches because they allow calculating them for different purposes. We first carry out sensitivity analysis of input coefficients (section 2) and we compute Chenery and Watanabe and Rasmussen multipliers (section 3). These variables focus on the linkages and therefore the key sectors under these approaches are the ones that need a higher amount of inputs or their production is a main input for other sectors. As it could be expected, the key sectors tend to be part of the primary sector and manufacturing activities. Also are considered key sectors under these approaches petroleum refineries, energy production and sometimes construction activities.

Nevertheless, there are other policy objectives such as environment conservation, reduction of imports and increase of export and reduction of unemployment. As per the high unemployment rate of Spain we focus on the last one and compute three multipliers (section 4): compensation to employees, total full-time jobs and full-time jobs excluding self-employed. The most desirable sector policy in Spain will promote the sectors that have a higher impact on employment but also supply chain effects of those policies included in the analysis (see Table 4).

Table 4

**Main results for Spain in 2009**

| Sector name | Sensitivity analysis of input coefficients | | Chenery and Watanabe multipliers | | | | Rasmussen multipliers | | | | | Labour-based multipliers | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MIC by rows | MIC by columns | DBL | DFL | TBL | TFL | $\varphi_j$ | $\pi_j$ | $\tau_j$ | Key sectors (type I) | Key sectors (type II) | compensation to employees | total full-time jobs | full-time jobs excluding self-employed |
| Farming | 4 | 1 | 1,28 | 0,45 | 3,15 | 2,16 | 3,12 | 2,78 | 1,30 | | +++ | 0,308 | 0,027 | 0,017 |
| Forestry and logging | 0 | 0 | 0,10 | 0,15 | 1,27 | 1,35 | 6,62 | 2,46 | 1,13 | | +++ | 0,295 | 0,028 | 0,024 |
| Fishing | 0 | 2 | 0,04 | 0,59 | 1,06 | 2,62 | 8,48 | 2,62 | 1,10 | - | +++ | 0,582 | 0,024 | 0,018 |
| Mining and quarrying | 2 | 1 | 1,11 | 0,61 | 6,05 | 2,53 | 1,69 | 1,95 | 1,55 | +++ | +++ | 0,566 | 0,017 | 0,016 |
| Animal slaughtering, rendering, and processing | 0 | 1 | 0,30 | 0,80 | 1,45 | 2,90 | 7,63 | 2,32 | 1,06 | | +++ | 0,454 | 0,023 | 0,018 |
| Milk and derivatives manufacturing | 0 | 2 | 0,12 | 0,79 | 1,16 | 2,89 | 8,55 | 1,88 | 1,33 | - | +++ | 0,460 | 0,020 | 0,016 |
| All other food manufacturing | 3 | 1 | 0,87 | 0,76 | 2,96 | 2,85 | 4,16 | 1,55 | 1,49 | | +++ | 0,483 | 0,022 | 0,018 |
| Beverages manufacturing | 0 | 2 | 0,26 | 0,69 | 1,36 | 2,68 | 6,93 | 1,89 | 1,15 | | +++ | 0,485 | 0,017 | 0,014 |
| Tobacco product manufacturing | 0 | 1 | 0,04 | 0,49 | 1,05 | 2,06 | 8,55 | 2,00 | 0,96 | - | + | 0,449 | 0,014 | 0,012 |
| Fabric mills | 0 | 1 | 0,51 | 0,67 | 1,87 | 2,65 | 5,40 | 1,66 | 1,06 | | +++ | 0,595 | 0,022 | 0,020 |
| Textile mills | 0 | 0 | 0,31 | 0,69 | 1,52 | 2,71 | 6,79 | 1,97 | 0,61 | | + | 0,629 | 0,024 | 0,022 |
| Leather and allied product manufacturing | 0 | 0 | 0,29 | 0,65 | 1,41 | 2,60 | 7,84 | 1,47 | 1,16 | | +++ | 0,588 | 0,025 | 0,022 |
| Pulp mills | 0 | 0 | 0,67 | 0,67 | 2,50 | 2,63 | 4,69 | 1,84 | 0,73 | | + | 0,606 | 0,024 | 0,022 |
| Paper mills | 0 | 0 | 0,81 | 0,71 | 2,86 | 2,75 | 3,83 | 1,28 | 1,23 | | +++ | 0,552 | 0,018 | 0,016 |
| Paperboard mills and printing | 0 | 0 | 0,59 | 0,57 | 2,28 | 2,34 | 4,26 | 1,24 | 1,19 | | +++ | 0,606 | 0,021 | 0,019 |
| Petroleum refineries | 5 | 1 | 1,19 | 0,96 | 4,51 | 3,59 | 2,99 | 1,37 | 0,94 | | + | 0,566 | 0,017 | 0,015 |
| Chemical manufacturing | 4 | 0 | 1,77 | 0,74 | 6,42 | 3,00 | 1,99 | 1,19 | 1,19 | +++ | +++ | 0,547 | 0,015 | 0,014 |
| Pharmaceutical preparation manufacturing | 0 | 1 | 0,27 | 0,71 | 1,41 | 2,79 | 6,97 | 1,02 | 1,27 | | +++ | 0,554 | 0,015 | 0,014 |
| Plastics products and rubber manufacturing | 0 | 1 | 1,01 | 0,65 | 3,41 | 2,68 | 3,08 | 1,35 | 0,91 | | + | 0,569 | 0,017 | 0,016 |
| Miscellaneous nonmetallic mineral products | 0 | 0 | 0,46 | 0,65 | 2,21 | 2,58 | 4,84 | 1,17 | 1,12 | | +++ | 0,577 | 0,018 | 0,016 |
| Iron and steel mills and ferroalloy manufacturing | 2 | 0 | 1,09 | 0,79 | 4,33 | 3,07 | 2,48 | 1,08 | 1,14 | +++ | +++ | 0,560 | 0,016 | 0,015 |
| Fabricated metal manufacturing, except machinery and equipment | 1 | 1 | 1,22 | 0,62 | 4,36 | 2,65 | 2,37 | 1,44 | 0,74 | +++ | + | 0,607 | 0,019 | 0,017 |

| Sector name | Sensitivity analysis of input coefficients | | Chenery and Watanabe multipliers | | | | Rasmussen multipliers | | | | | Labour-based multipliers | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MIC by rows | MIC by columns | DBL | DFL | TBL | TFL | $\varphi_j$ | $\pi_j$ | $\tau_j$ | Key sectors (type I) | Key sectors (type II) | compensation to employees | total full-time jobs | full-time jobs excluding self-employed |
| Hardware and electronic products manufacturing | 0 | 0 | 0,62 | 0,63 | 2,32 | 2,45 | 4,29 | 1,17 | 1,00 | | + | 0,626 | 0,019 | 0,018 |
| Electrical equipment and household appliances manufacturing | 0 | 1 | 0,58 | 0,73 | 2,37 | 2,93 | 4,30 | 1,18 | 0,94 | | + | 0,595 | 0,017 | 0,016 |
| Other industrial machinery manufacturing | 0 | 1 | 0,69 | 0,61 | 2,71 | 2,59 | 3,57 | 0,76 | 1,34 | | + | 0,602 | 0,017 | 0,016 |
| Vehicle manufacturing | 6 | 0 | 1,16 | 0,82 | 3,59 | 3,44 | 3,84 | 1,20 | 0,91 | | + | 0,629 | 0,018 | 0,017 |
| All other transportation equipment manufacturing | 0 | 1 | 0,07 | 0,76 | 1,12 | 3,09 | 8,49 | 1,00 | 1,06 | - | +++ | 0,619 | 0,017 | 0,016 |
| Furniture manufacturing | 0 | 0 | 0,24 | 0,56 | 1,49 | 2,41 | 6,13 | 0,96 | 1,12 | | + | 0,624 | 0,025 | 0,021 |
| Other engine equipment manufacturing | 0 | 0 | 0,15 | 0,53 | 1,20 | 2,22 | 7,38 | 0,99 | 1,01 | | + | 0,569 | 0,021 | 0,018 |
| Machinery and equipment repair and maintenance | 0 | 1 | 0,75 | 0,46 | 2,74 | 2,16 | 3,51 | 0,81 | 1,15 | | + | 0,611 | 0,019 | 0,017 |
| Electric power generation and transmission, and natural gas distribution | 1 | 2 | 1,55 | 0,63 | 5,68 | 2,61 | 2,09 | 0,63 | 1,26 | + | + | 0,369 | 0,011 | 0,010 |
| Water, sewage and other systems | 0 | 1 | 0,23 | 0,50 | 1,45 | 2,20 | 6,49 | 0,90 | 0,92 | | - | 0,491 | 0,014 | 0,013 |
| Waste management and remediation services | 0 | 0 | 0,56 | 0,67 | 2,75 | 2,75 | 4,22 | 1,10 | 0,70 | | + | 0,588 | 0,018 | 0,017 |
| Construction | 1 | 0 | 1,33 | 0,53 | 4,62 | 2,21 | 2,67 | 0,66 | 1,17 | | + | 0,468 | 0,016 | 0,014 |
| Automotive repair and maintenance | 0 | 1 | 0,17 | 0,47 | 1,42 | 2,18 | 6,14 | 0,95 | 0,88 | | - | 0,591 | 0,021 | 0,018 |
| Wholesale and retail trade | 0 | 0 | 0,27 | 0,41 | 1,58 | 1,88 | 5,42 | 0,61 | 1,21 | | + | 0,570 | 0,023 | 0,018 |
| Rail transportation | 0 | 1 | 0,06 | 0,57 | 1,11 | 2,48 | 8,19 | 0,78 | 1,03 | - | + | 0,581 | 0,015 | 0,014 |
| Truck, pipeline, transit and ground passenger transportation | 0 | 1 | 1,00 | 0,54 | 3,82 | 2,44 | 2,49 | 0,48 | 1,34 | + | + | 0,553 | 0,021 | 0,016 |
| Water transportation | 0 | 1 | 0,05 | 0,75 | 1,10 | 2,94 | 8,45 | 0,93 | 0,82 | - | - | 0,501 | 0,016 | 0,014 |
| Air transportation | 0 | 2 | 0,45 | 0,75 | 1,76 | 3,10 | 5,87 | 0,59 | 1,16 | | + | 0,623 | 0,015 | 0,014 |
| Warehousing and storage | 0 | 0 | 1,57 | 0,61 | 5,37 | 2,45 | 2,28 | 0,50 | 1,25 | + | + | 0,546 | 0,016 | 0,014 |
| Postal service, couriers and messengers | 0 | 0 | 0,22 | 0,48 | 1,44 | 2,08 | 6,45 | 0,61 | 1,13 | | + | 0,731 | 0,027 | 0,026 |

| Sector name | Sensitivity analysis of input coefficients | | Chenery and Watanabe multipliers | | | | Rasmussen multipliers | | | | | Labour-based multipliers | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MIC by rows | MIC by columns | DBL | DFL | TBL | TFL | $\varphi_j$ | $\pi_j$ | $\tau_j$ | Key sectors (type I) | Key sectors (type II) | compensation to employees | total full-time jobs | full-time jobs excluding self-employed |
| Accommodation | 0 | 0 | 0,45 | 0,38 | 1,68 | 1,84 | 5,00 | 0,84 | 0,86 | | - | 0,574 | 0,021 | 0,020 |
| Food and drinking places | 0 | 0 | 0,12 | 0,37 | 1,20 | 1,93 | 7,08 | 0,67 | 1,03 | | + | 0,356 | 0,017 | 0,013 |
| Publishers | 0 | 0 | 0,39 | 0,58 | 1,79 | 2,37 | 5,10 | 0,54 | 1,17 | | + | 0,576 | 0,017 | 0,015 |
| Motion picture and video industries, sound recording, radio and TV broadcasting | 0 | 0 | 0,31 | 0,61 | 1,54 | 2,38 | 6,81 | 0,48 | 1,27 | | + | 0,571 | 0,017 | 0,015 |
| Telecommunications carriers | 0 | 0 | 0,87 | 0,51 | 3,13 | 2,09 | 3,41 | 0,64 | 1,04 | | + | 0,347 | 0,009 | 0,008 |
| Data processing, hosting, and related services | 0 | 0 | 0,43 | 0,49 | 1,94 | 1,99 | 5,20 | 0,66 | 0,93 | | - | 0,683 | 0,019 | 0,017 |
| Financial investment services | 0 | 0 | 1,61 | 0,21 | 4,56 | 1,40 | 2,09 | 0,63 | 0,95 | + | - | 0,429 | 0,008 | 0,008 |
| Insurance carriers | 0 | 0 | 0,27 | 0,56 | 1,54 | 2,15 | 6,31 | 0,79 | 0,77 | | - | 0,408 | 0,012 | 0,010 |
| Funds, trusts, brokerages, and related activities | 0 | 0 | 0,59 | 0,53 | 2,08 | 2,12 | 5,32 | 0,73 | 0,80 | | - | 0,429 | 0,017 | 0,012 |
| Real estate | 0 | 0 | 0,74 | 0,34 | 2,55 | 1,61 | 3,42 | 0,66 | 0,86 | | - | 0,194 | 0,006 | 0,005 |
| Attributed property income | 0 | 0 | 0,00 | 0,33 | 1,00 | 1,56 | 8,69 | 0,46 | 1,14 | - | + | 0,146 | 0,004 | 0,003 |
| Legal, accounting, tax preparation, bookkeeping, and payroll services | 0 | 0 | 1,03 | 0,37 | 3,32 | 1,70 | 2,97 | 0,61 | 0,94 | | - | 0,554 | 0,022 | 0,016 |
| Architectural, engineering, and related services | 0 | 0 | 0,66 | 0,52 | 2,77 | 2,10 | 3,92 | 0,62 | 0,90 | | - | 0,584 | 0,020 | 0,016 |
| Scientific research and development services | 0 | 0 | 0,37 | 0,38 | 1,82 | 1,79 | 4,64 | 0,48 | 1,07 | | | 0,749 | 0,021 | 0,020 |
| Advertising, public relations, marketing research and related services | 0 | 0 | 0,79 | 0,58 | 2,71 | 2,31 | 3,80 | 0,68 | 0,81 | | - | 0,604 | 0,021 | 0,018 |
| Veterinary services and other professional activities | 0 | 0 | 0,53 | 0,42 | 2,15 | 1,90 | 4,58 | 0,52 | 0,96 | | - | 0,528 | 0,025 | 0,016 |
| Facilities support services | 0 | 0 | 0,57 | 0,45 | 2,19 | 2,03 | 4,32 | 0,56 | 0,86 | | - | 0,373 | 0,013 | 0,011 |
| Employment services | 0 | 0 | 0,18 | 0,15 | 1,39 | 1,29 | 6,17 | 0,52 | 0,90 | | - | 0,907 | 0,041 | 0,041 |
| Travel arrangement and reservation services | 0 | 0 | 0,16 | 0,73 | 1,24 | 2,70 | 7,98 | 0,52 | 0,87 | | - | 0,594 | 0,020 | 0,018 |
| Investigation and security services, services to buildings and dwellings and | 0 | 0 | 1,35 | 0,33 | 4,24 | 1,68 | 2,32 | 0,59 | 0,77 | | - | 0,788 | 0,036 | 0,033 |

| Sector name | Sensitivity analysis of input coefficients | | Chenery and Watanabe multipliers | | | | Rasmussen multipliers | | | | | Labour-based multipliers | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MIC by rows | MIC by columns | DBL | DFL | TBL | TFL | $\Phi_j$ | $\Pi_j$ | $\tau_j$ | Key sectors (type I) | Key sectors (type II) | compensation to employees | total full-time jobs | full-time jobs excluding self-employed |
| other support activities | | | | | | | | | | | | | | |
| Government, defense and social insurance | 0 | 0 | 0,03 | 0,30 | 1,05 | 1,66 | 7,99 | 0,45 | 0,89 | + | - | 0,722 | 0,021 | 0,020 |
| Educational services | 0 | 0 | 0,19 | 0,14 | 1,40 | 1,31 | 6,02 | 0,52 | 0,84 | | - | 0,802 | 0,020 | 0,019 |
| Health care services | 0 | 0 | 0,21 | 0,34 | 1,35 | 1,78 | 6,68 | 0,46 | 0,80 | | - | 0,740 | 0,019 | 0,018 |
| Community care facilities and services | 0 | 0 | 0,00 | 0,41 | 1,00 | 1,91 | 8,42 | 0,43 | 0,83 | - | - | 0,708 | 0,024 | 0,023 |
| Performing art companies, museums , libraries archives, other information services and gambling industries | 0 | 0 | 0,19 | 0,46 | 1,30 | 1,98 | 7,02 | 0,46 | 0,72 | | - | 0,580 | 0,020 | 0,018 |
| Spectator sports, promoters of performing arts and sports and amusement parks and arcades | 0 | 0 | 0,34 | 0,48 | 1,53 | 1,98 | 6,10 | 0,61 | 0,57 | | - | 0,718 | 0,021 | 0,019 |
| Civic, social, professional, grantmaking, giving, and social advocacy organizations | 0 | 0 | 0,09 | 0,49 | 1,20 | 2,07 | 7,04 | 0,60 | 0,56 | | - | 0,720 | 0,025 | 0,023 |
| Personal and household goods repair and maintenance | 0 | 0 | 0,13 | 0,44 | 1,19 | 2,01 | 7,71 | 0,43 | 0,68 | | - | 0,585 | 0,027 | 0,020 |
| Other personal services | 0 | 0 | 0,05 | 0,38 | 1,07 | 1,86 | 7,95 | 0,55 | 0,58 | | - | 0,554 | 0,039 | 0,027 |

Source: Authors' elaboration.

In the case of Rasmussen type I the key sectors are (+++), the sectors with concentrated high pushing effect (+) and the sectors with lowest linkages with (-). For Rasmussen type II key sectors are (+++) too, pushing and strategic sectors are (+) and independent sectors (-).

This document should be considered a first approach to the topic by the authors. We are going to replicate the analysis hereby presented for the years 2000 to 2009 in order to discover trends on relative sector importance and determine if the current crisis had an effect on multipliers. We also will follow the same approach at regional level to combine findings of sector and regional policies.

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# 7. APPENDIX

Table A1

**Sector simplifications in 2009 input-output matrix**

| Rows | Columns | Rows | Columns |
|---|---|---|---|
| Agriculture | Farming | Motor vehicles manufacturing | Vehicle manufacturing |
| Animal husbandry | | Parts for motor vehicles and trailer manufacturing | |
| Services to farming and agriculture | | Ships and boats manufacturing | |
| Coal and lignite mining | Mining and quarrying | Railway locomotives manufacturing | |
| Oil wells | | Aircraft and spacecraft manufacturing | |
| Natural gas wells | | Electric power generation and transmission | Electric power generation and transmission, and natural gas distribution |
| Metal mining | | Natural gas distribution and air conditioned supply | |
| Non-metallic and energy minerals mining | | Residential buildings works | Construction |
| Animal and vegetable oils and fats manufacturing | All other food manufacturing | Non-residential buildings works | |
| Animal feeding products manufacturing | | Civil engineering works | |
| Other food products manufacturing | | Specialized construction works | |
| Alcoholic beverages manufacturing | Beverages manufacturing | Motor vehicles, parts and accessories retail | Automotive repair and maintenance |
| Non-alcoholic beverages manufacturing | | Maintenance and repair of motor vehicles | |
| Paper and cardboard manufacturing | Paper mills | Truck, pipeline, transit and ground passenger transportation | passenger transportation |
| Paper and cardboard products manufacturing | | | Truck, pipeline, transit and ground transportation |

| Rows | Columns | Rows | Columns |
|---|---|---|---|
| Basic chemicals, nitrogen compounds, fertilizers, plastics and synthetic rubber in primary forms; pesticides and other agrochemicals manufacturing | Chemical manufacturing | Warehousing and storage services | Warehousing and storage |
| Other chemicals manufacturing | | Logistics | |
| Artificial and synthetic fibers manufacturing | | Motion picture and video industries and sound recording | Motion picture and video industries, sound recording, radio and TV broadcasting |
| Rubber manufacturing | Plastics products and rubber manufacturing | Radio and TV broadcasting | |
| Plastic products manufacturing | | Other professional activities | Veterinary services and other professional activities |
| Glass manufacturing | Miscellaneous nonmetallic mineral products | Veterinary services | |
| Ceramic manufacturing | | Vehicle rental services | Rental services |
| Cement and concrete manufacturing | | Household appliances and industrial machinery rental services | |
| Other non-metallic mineral products manufacturing | | Investigation and security services | Investigation and security services, services to buildings and dwellings and other support activities |
| Electronic components and electronic boards manufacturing | Hardware and electronic products manufacturing | services to buildings and dwellings | |
| Computers and related devices manufacturing | | other support activities | |
| Other electronic and optical equipment manufacturing | | Performing art companies | Performing art companies, museums , libraries archives, other information services and gambling industries |
| Electrical equipment manufacuring except household appliances | Electrical equipment and household appliances manufacturing | libraries archives and other information services | |
| Household Appliances manufacturing | | gambling industries | |

Source: Authors' elaboration

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